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# APPLICATION FOR UNITED STATES LETTERS PATENT

## SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

Be it known that Gregory T. Kohler  
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 in the County of \_\_\_\_\_ and State of \_\_\_\_\_  
 have invented a new and useful TANK AND CAP ASSEMBLY FOR USE WITH  
MICROCHANNEL TUBING IN A HEAT EXCHANGER  
 of which the following is a specification.

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-1-

## TANK AND CAP ASSEMBLY FOR USE WITH MICROCHANNEL TUBING IN A HEAT EXCHANGER

### FIELD OF THE INVENTION

This invention relates to heat exchangers, and more particularly, to a tank and cap assembly for use with microchannel tubing employed in the fabrication of heat exchangers.

### BACKGROUND OF THE INVENTION

Recent years have seen a considerable increase in the use of extruded, aluminum tubing in the fabrication of heat exchangers. Frequently, the aluminum tubing is of flattened cross section (also frequently and synonymously referred to as "oval cross section") having a minor dimension and a major dimension. In the usual case, a plurality of individual ports extend from end to end within the tubing and are arranged, typically in one row, along the major dimension of the tube. The ports are frequently square or rectangular in cross section but in some instances may be triangular or even trapezoidal in cross section. In frequent instances, they may be circular in cross section. Port dimensions range from relatively large size ports having hydraulic diameters of 10 millimeters or more down to unusually small ports whose hydraulic diameters are 1.8 millimeters or less.

Tubes having ports of relatively small hydraulic diameters, i.e., 1.8 millimeters or less, are frequently referred to as "microchannel" tubes. Presumably this is because of the small hydraulic diameter of the individual ports or channels.

-2-

In any event, before tubes of any sort may be employed usefully in a heat exchanger, means must be provided on the ends of each section of tubing for connecting the tubing into the hydraulic circuit, including the ports within the tube or tubes, in which a fluid heat exchange medium passes. Because it is not practical to form fittings or the like integrally with the ends of an extruded tube, the various components used to connect the tube into the hydraulic circuit are typically fabricated separately and placed on the ends of the tubes. This, in turn, means that the fittings must be sealed to the tube ends to avoid leakage, and such must be done in such a way that the sealing medium does not partially or entirely plug one or more of the ports in the tube. Of course, the plugging problems becomes more acute as port size is reduced. Hence, the possibility of plugging of the ports in microchannel tubing as a result of the sealing operation is much greater than that which exists for tubes having relatively large ports, i.e., ports of relatively large hydraulic diameter.

In the usual case, brazing is the method of choice in sealing aluminum heat exchanger components to one another because it metallurgically bonds the components together in assembled relation as well. The components are assembled to one another and held in assembled relation through a brazing process which accomplishes a permanent bond and seal between the various components. It is therefore highly desirable that assembly of the components to one another be easily accomplished with a minimal chance of error.

The present invention is, therefore, directed to heat exchanger assemblies and components therefore that overcome one or more of the

-3-

above problems and/or to provide one or more of the above recited desirable features.

#### SUMMARY OF THE INVENTION

It is the principal object of the invention to provide a new and improved heat exchanger. More specifically, it is a principal object of the invention to provide an improved assembly for placement on the end of a piece of tubing whereby the tubing may be connected into a heat exchange circuit.

A preferred embodiment of the invention achieves the foregoing objects in a heat exchanger which includes a flattened tube including an interior port that extends to an end of the tube. A cap is provided and has a generally centrally located slot sized to snugly receive the tube end and allow the tube to pass fully through the cap. The cap has a body in which the slot is formed and the body has an exterior surface nominally concentric with the slot. The exterior surface has a tube facing side and an opposite side spaced therefrom and the periphery of the cap at the tube facing side is larger than the opposite side. Also included is a tank having a body with a cap receiving end, a fluid receiving or discharging end spaced from the cap receiving end, an interior cavity opening to the cap receiving end and a port extending from the cavity at a location remote from the cap receiving end to a location at or near the receiving or discharging end. The cavity has a stepped wall including a first section sized to snugly receive the tube facing side of the cap and a second section spaced from the first section and sized to abut the tube end

-4-

without blocking the internal port thereat. An intermediate section is disposed between the first and second sections and is sized to abut the cap at a location between the tube facing side and the opposite side when the tube facing side is received in the first section. The tank receives the cap with the intermediate section acting as a cap stop to limit entry of the cap into the tank and the second section acting as a tube stop limiting entry of the tube into the cavity.

One embodiment of the invention contemplates that the cap have a flat tube facing side and an opposite crowned side. A collar is located on the body of which the cap is formed and is disposed about the slot and located on the opposite crowned side. The interior cavity in the tank has an oval cross section and there is further included a stub on the fluid receiving and discharging end of the tank body such that the port in the tank body extends through the stub. The first, second and intermediate sections of the interior cavity on the tank are oval shaped, and in a preferred embodiment, the second section is both domed and oval shaped.

According to another aspect of the invention, the cap has a flat, disc-like body and a collar is located on the body disposed about the slot and located on the opposite side of the cap. The interior cavity of the tank has an oval cross section. The port within the tank body opens to one side of the body.

In a preferred embodiment, the exterior of the cap, intermediate the sides thereof is a convex shaped dome.

In a preferred embodiment, the slot in the cap has a flared concave end at the tube receiving side.

In a preferred embodiment, at least one tang is located at the interface of the tube and the slot and is sized to provide an interference fit between the tube and the cap to hold the tube in the slot during assembly without preventing disposition of the tube in the slot. Even more preferably, the tang is on the cap within the slot and engages a wall of the tube.

Other objects and advantages will become apparent from the following specification taken in connection with the accompanying drawings.

#### DESCRIPTION OF THE DRAWINGS

Fig. 1 is an exploded view of part of a heat exchanger made according to the invention;

Fig. 2 shows the components of Fig. 1 in assembled relation with parts broken away for clarity;

Fig. 3 is an exploded view of two of the components illustrated in Figs. 1 and 2 but taken from a different angle;

Fig. 4 is a view similar to Fig. 3 but of a modified embodiment of the invention;

Fig. 5 illustrates a modified embodiment of a tank used in the invention;

Fig. 6 is an enlarged fragmentary view of a slot employed in a cap utilized in the invention; and

Fig. 7 is a sectional view taken approximately along the line 7-7 in Fig. 6.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

An exemplary embodiment of a heat exchanger made according to the invention is somewhat fragmentarily shown in Fig. 1. The same is seen to include three major components, although in real life, one or more additional components (not shown) will be required. Included is a piece of tubing, generally designated 10, having an end 12 which is received in a cap, generally designated 14. The cap 14 is, in turn, received within a tank, generally designated 16. As will be seen, the tank 16 is adapted to be connected into the hydraulic circuit for a heat exchange fluid that is to be passed through the tube 10.

Returning to the tube 10, the same is what is generally referred to as flat or oval cross section and has a major dimension  $D_M$  which extends between opposed end walls 18 of the tube 10 and at a minor dimension  $D_m$  which extends between opposed side walls 20 of the tube 10.

As clearly apparent from Fig. 1, the tube has a plurality of internal channels or ports 22 that extend from end to end of the tube. As illustrated, the vast majority of the ports are triangular or trapezoidal but they could have any desired cross section. Where the tube 10 is a microchannel tube, the ports 22 will have a relatively small hydraulic diameter, that is, about 1.8 millimeters or less.

In the usual case, the tube 10 will be an extruded aluminum tube. The tube 10, when made of aluminum, preferably is, but need not be, free of braze alloy for reasons that will be seen. If desired, the tube 10 may be convoluted into a plurality of series connected, back and forth

-7-

straight runs to provide a so-called "serpentine" heat exchanger. Alternatively, the same could be simply straight or U shaped to define a hairpin type of tube. Thus, the particular configuration of the tube 10 can be anything that one desires to suit any particular use to which the heat exchanger is to be put.

Turning now to the cap 14, the same may be die formed out of aluminum to have a tube receiving end 24 and an opposite end 26 which is spaced from the tube receiving end 24. As best seen in Figs. 1 and 3, the same has an approximately centrally located tube receiving slot 28 that extends through a collar 30 on the opposite side 26 of the cap 14. The slot 28 is configured to snugly receive the tube 10, that is, the slot 28 will have dimensions ever so slightly larger than the tube major dimension  $D_M$  and the tube minor dimension  $D_m$  with rounded ends that approximate the end walls 18. In one embodiment of the invention, it is contemplated that the tube 10 be freely receivable within the slots 28 but with the minimum of clearance between the tube walls and the edges of the slot 28, which preferably should be no more than about 0.005 inches and preferably is in the range of 0.001-0.003 inches. In another embodiment of the invention, a slight interference is caused to exist as will be seen.

The cap 14 also includes an interior cavity 32 which is of a domed configuration and which emerges to the tube receiving side 24 of the cap 14 at an opening 34. The opening 34 may be regarded as generally concentric with the slot 28 and the tube 10 but of larger size, which is to say, the opening 34 is flared outwardly with respect to the various walls and the slot 28 of the tube 10.

-8-

According to a preferred embodiment, the cap 14 will also be formed of aluminum and will have braze alloy on the exterior as well as on the surface of the interior cavity 32 and the slot 28. That is to say, the cap 14 is double-side braze clad.

5 Referring to Figs. 1 and 3, the tank 16 may be impact extruded from a metallic body, preferably aluminum, to have a cap receiving end 40 and an opposite, fluid receiving or discharging end 42. A generally cylindrical stub 44 for connection into a heat exchange fluid circuit is located on the fluid receiving or discharging end 42 and includes an interior port 46 (Fig. 3) which opens through the stub 44 at the fluid receiving and discharging end 42. Inwardly of the body of the tank 16, the port 46 extends to an interior cavity 48 which opens to the cap receiving end 40. Typically, but not always, the port 46 and/or the stub 44 will be provided with a connection facilitating structure (not shown) such as threads, a tubular flare, a braze cup or the like.

10 The interior of the cavity 48 is stepped as can be plainly seen in Fig. 3 and includes a first section 50 which is sized to snugly receive the periphery of the cap 14 at its tube receiving end 24. The cavity 48 includes a second section 52, spaced from the first section 50 and an intermediate section 54 that extends between the first section 50 and the second section 52. A peripheral shoulder 56 is located at the interface of the first section 50 and the intermediate section 54 while a similar, but smaller shoulder 58 is located at the interface of the intermediate section 54 and the second section 52.

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-9-

It is to be noted that the sections 50,52,54 are oval-shaped in cross section at any section taken transverse to the axis of the port 46.

As seen in Fig. 2, the intermediate section 54 is sized to receive the collar 30 on the cap 14 with the shoulder 58 being such as to engage the end 12 of the tube 10 when the same is inserted through the slot 28. That is, the shoulder 58 is sized to overlie the walls of the tube 10 at its end 12. The shoulder 58 is also sized so that no part of it appreciably overlies any one of the ports 22 at the end 12 to avoid blockage thereat. Accordingly, the shoulder 58 acts as a stop to limit movement of the tube 10 through the cap 14 into the interior of the cavity 48 so that the dome-shaped second section 52 acts as a fluid collecting space for the port 46.

The shoulder 56 is located so as to abut the dome-shaped exterior surface 26 on the cap 14 when the cap 14 has been inserted into the cavity 48 to a point where the tube receiving end 24 of the cap 14 is approximately flush with the cap receiving end 40 of the tank 16 as seen in Fig. 2. Thus, the shoulder 56 acts as a stop to limit entry of the cap 14 into the cavity 48 in the tank 16.

In the usual case, all surfaces of the tank 16 are free of braze alloy or braze cladding. Thus, in a preferred embodiment, only the cap 14 is braze clad and it is a double braze clad element. As a consequence of this construction, the expense of braze cladding the tube 10 and the tank 16 is avoided and yet there is sufficient braze clad material on both the interior and exterior surfaces of the cap 14 that when the components are assembled as illustrated in Fig. 2 and subject to a brazing temperature, the

-10-

braze cladding will flow to bond and seal the exterior face of the tube 10 with the cap 14 within the slot 28 and to seal the interface of the cap 14 with the tank 16 at their interface adjacent the tube receiving end 24 of the cap 14 and the cap receiving end 40 of the tank 16.

5 It will be observed in Fig. 2 that the flaring of the cavity 32 in the cap 14 adjacent the tube receiving end 24 provides a piloting action when the tube end 12 is inserted into the slot 28. Any misalignment of the tube 12 and the slot 28 is immediately accommodated by the camming action provided by the flare of the cavity 32 to cause the end 12 to shift to move into alignment with and penetrate the slot 28.

As alluded to previously, on the end of the tube 10 opposite the end 12, another fitting will be applied to connect the tube 10 into a heat exchanger fluid circuit. In the usual case, the fitting applied at such end may be substantially identical to that illustrated in the drawings herein but alternatively may be any type of fitting that the user wishes to apply thereto including a fitting, such as a header or manifold, that could receive the ends of multiple ones of the tubes 10.

Turning now to Fig. 4, an alternative embodiment of the invention is illustrated. Where like components are utilized, like reference numerals are used. In the embodiment shown in Fig. 4, the cap 14 is a generally flat disc-like element 60 having a tube receiving end 62 and an opposite end 64. A collar 66 is disposed on the opposite end 64 about a slot 28 that extends through the disc-like element 60. The cap illustrated in Fig. 4 may be utilized with tank 16 illustrated in Figs. 1, 2 and 3 al-

-11-

though typically, the distance between the cap receiving end 40 and the shoulder 56 will be reduced to the thickness of the disc-like element 60.

Fig. 4 also illustrates a modified embodiment of the tank 16. In this embodiment, rather than having the second section 52 of the cavity 32 dome-shaped, it is of uniform, oval cross section throughout as illustrated at 70. Again, a stub 44 together with a port 46 is provided. In this embodiment, the tank 16 may be milled to the configuration shown rather than impact extruded.

In general, the embodiment of the tank 16 illustrated in Fig. 3 is preferred over that shown in Fig. 4 because the dome-like shape of the second section 52 of the cavity 48 in the tank 16 provides for a better redirection of the fluid entering the cavity 48 from the tube end 12 to the port 46.

Still another embodiment is illustrated in Fig. 5. In the embodiment illustrated in Fig. 5, a modified tank structure 16 is shown. In this embodiment, the stub 44 is omitted along with the axial port 46 therein. In lieu of the port 46, a sideways directed port 74 is located closely adjacent the receiving or discharging end 42 of the body forming the tank 16. The interior cavity 48 again opens to the cap receiving end 40 of the tank 16 and may have the configuration illustrated in either of the embodiments heretofore described, that is, it may have the configuration illustrated in Fig. 3 or it may have the configuration illustrated in Fig. 4.

It will thus be appreciated that selection of a particular one of the caps 16 can be made dependent upon the place of installation of the

-12-

heat exchanger and the location at which the connection of the port 46 or 74 is to be made.

Fig. 6 illustrates a preferred feature of the invention that is applicable to either form of cap disclosed and described above. In particular, opposite side walls 80,82 of the slot 28 in the cap 14, which will align with the side walls of the tube 10 are provided with inwardly directed, generally V-shaped tangs 84. The tangs 84 narrow the space between the side walls 80,82 at the location of the tangs 84 to a distance that is a few thousandths of an inch less than the minor dimension  $D_m$  of the tube 10. As a consequence, a slight interference fit exists. The interference is insufficient to prevent easy insertion of a tube 10 into the slot 28 but is sufficient to hold the tube 10 in the slot 28 once it is introduced therein to provide a self-fixturing action during the brazing process. That is to say, the interference fit is sufficient to prevent the tube 10 from falling out of the cap 14 or the cap 14 from falling off of the end 12 of the tube 10 without preventing insertion of the tube end 12 in the cap 14.

Fig. 7 also show a preferred feature of the invention as applied to the embodiment of the cap 14 illustrated in Fig. 4. In particular, it will be noted that the slot 28, at its point of emergence with the tube receiving end 62 of the flat, disc-like element 60, is surrounded by a relatively generous round 88.

The round 88 provides a piloting action for insertion of the end 12 of the tube 10 into the embodiment of the cap 14 illustrated in Fig. 4 just as the enlarged opening 34 to the cavity 32 of the cap 14 illustrated in Figs. 1, 2 and 3 provides piloting action for the end 12 of the tube 10.

-13-

It will also be observed that the cap of the embodiment illustrated in Figs. 4 and 7 is double braze clad, i.e., braze clad on both sides so that there will be braze alloy within the slot 28 as well as on the periphery of the flat, disc-like element 60.

5 In the usual course, the cap 14 will be installed within the cavity 48 as generally described previously. At locations shown at 90 in Fig. 1, the tank 16 will be staked, punched or peened over the cap 14, to grasp the cap 14 and hold the same within the cavity 48 in the tank 16 and in abutment with the shoulder 56 to provide self-fixturing during brazing.

10 From the foregoing, it will be appreciated that a heat exchanger made according to the invention is simple and easy to assemble. The piloting action for the end of the tube 12 simplifies assembly and the parts are basically self-fixturing when the tangs 84 and the staking, punching or peening is employed. The heat exchanger is extremely flexible simply by selection of an appropriate one of the tanks 16, dependent upon the exit or entry direction of the heat exchange fluid that is desired and thus may be used in a large variety of settings.

15 Because braze clad or braze alloy is located only on the cap 14, and the end 12 of the tube 10 is located inwardly of the cap 14 against the shoulder 58 as can be appreciated from Fig. 2, braze alloy is unlikely to migrate during brazing to the end 12 of the tube and plug any of the ports 22, a particularly important feature when the tube 10 is a so-called microchannel tube. Similarly, the construction of the shoulder 58 assures that the tube 10 cannot be inserted too far into the tank 16 and

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-14-

yet avoids any blockage of the ports 22 that could interfere with subsequent operation.

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